

FINAL TECHNICAL REPORT FOR NASA GRANT NAGW-1980
ENTITLED 'CONSTRAINTS ON PALEOENVIRONMENTS'

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The purpose of this investigation was to study factors influencing the environment of the early Earth and the origin of life. A complete list of journal articles and book chapters published during the time period of the grant is attached. Below, I briefly describe what this research was about. The factors studied fall into four categories:

1) Atmospheric CO₂ levels and climate -- I published several articles (e.g. Kasting, 1989; Kasting and Toon, 1989) arguing that Earth's long-term climate is buffered by a negative feedback mechanism involving the carbonate-silicate cycle. This feedback mechanism may explain why the early Earth was warm despite reduced solar luminosity.

2) Sulfur and UV screens -- Was there any shield against solar ultraviolet radiation prior to the development of an ozone screen? Kasting et al. (Origins of Life 19: 95-108, 1989) argued that elemental sulfur vapor (S₈) may have provided such a screen if the early Earth was very warm.

3) Impacts and the origin of life -- Sleep et al. (1989) argued that the persistence of large, ocean-vaporizing impacts up until ~3.8 Ga before present may have led to repeated mass extinctions of surface-dwelling organisms prior to this time. Thus, life may have had to take refuge at the midocean ridges where it was thermally protected. Kasting (1990) showed that these same impacts could have led to an early atmosphere that was predominantly CO rather than CO₂.

4) Rare gases and the formation of the Earth -- Zahnle et al. (1990a,b) looked at various mechanisms for explaining the elemental and isotopic distribution patterns of the rare gases in planetary atmospheres. One conclusion is that hydrodynamic escape of hydrogen was probably an important process on all three terrestrial planets.

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PUBLICATIONS: NASA GRANT NAGW-1980

1989

Kasting, J.F. Long term stability of the Earth's climate. Palaeogeogr. Palaeoclimat. Palaeoecol. (Global Planet. Change sect.) 75: 83-95.

....., K.J. Zahnle, J.P. Pinto, and A.T. Young. Sulfur, ultraviolet radiation, and the early evolution of life. Origins of Life 19: 95-108.

..... and O.B. Toon. Climate evolution on the terrestrial planets. In: Origin and Evolution of Planetary and Satellite Atmospheres, S.K. Atreya, J.B. Pollack, and M.S. Matthews, eds., University of Arizona Press, Tucson, pp. 423-449.

Hunten, D.M., J.C.G. Walker, T.M. Donahue, and J.F. Kasting. Escape of atmospheres. In: Origin and Evolution of Planetary and Satellite Atmospheres, S.K. Atreya, J.B. Pollack, and M.S. Matthews, eds., University of Arizona Press, Tucson, pp. 386-422.

Sleep, N.H., K.J. Zahnle, J.F. Kasting, and H. Morowitz. Annihilation of ecosystems by large asteroid impacts on the early Earth. Nature 342: 139-142.

1990

Kasting, J.F. Bolide impacts and the oxidation state of carbon in the Earth's early atmosphere. Origins of Life 20: 199-231.

....., Earth, the living planet. The Planetary Report 10 (Jan/Feb): 8-9, cont. on 24.

....., Impacts and the origin of life. Earth and Mineral Sciences Bull. (Penn State Univ.) 59: 37-42.

Zahnle, K.J., J.F. Kasting, and J.B. Pollack. Mass fractionation of noble gases in diffusion-limited hydrodynamic hydrogen escape. Icarus 84: 502-527.

Zahnle, K.J., J.B. Pollack, and J.F. Kasting. Xenon fractionation in porous planetesimals. Geochim. Cosmochim. Acta 54: 2577-2586.

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Two graduate students were supported and worked on the research project listed above. Both students, Andrew Bailey and Bruce Francois, are enrolled as graduate students in the Department of Meteorology at The Pennsylvania State University.